

What is claimed is:

1. A method for forming a photoresist relief image on a substrate comprising:

(a) applying a coating layer of a chemically-amplified positive photoresist composition on a substrate, the photoresist composition comprising a resin and one or more photoacid generator compounds, wherein the one or more photoacid generator compounds are present in a concentration of at least about 5 weight percent based on weight of total solids of the photoresist composition;

(b) exposing the photoresist coating layer to radiation having a wavelength of less than about 160 nm, or electron beam or ion beam radiation.

2. A method for forming a photoresist relief image on a substrate comprising:

(a) applying a coating layer of a chemically-amplified positive photoresist composition on a substrate, the photoresist composition comprising a phenolic resin and one or more photoacid generator compounds, the resin comprising at least three distinct repeat units;

(b) exposing the photoresist coating layer to radiation having a wavelength of less than about 160 nm, or electron beam or ion beam radiation.

3. The method of claim 2 wherein the one or more photoacid generator compounds are present in a concentration of at least about 5 weight percent based on weight of total solids of the photoresist composition

4. The method of any one of claims 1 through 3 wherein the photoresist coating layer is exposed to EUV radiation.

5. The method of any one of claims 1 through 3 wherein the photoresist coating layer is exposed to electron beam or ion beam radiation.

6. The method of any one of claims 1 through 3 wherein the photoresist coating layer is exposed to x-ray radiation.

7. The method of any one of claims 1 through 6 wherein the one or more photoacid generator compounds are present in a concentration of at least about 6 weight percent based on weight of total solids of the photoresist composition.

8. The method of any one of claims 1 through 6 wherein the one or more photoacid generator compounds are present in a concentration of at least about 8, 9 or 10 weight percent based on weight of total solids of the photoresist composition.

9. The method of any one of claims 1 through 8 wherein the one or more photoacid generator compounds are present in a concentration up to about 12 weight percent based on weight of total solids of the photoresist composition.

10. The method of any one claims 1 through 6 wherein the one or more photoacid generator compounds are present in a concentration of from about 10 to about 15 weight percent of total solids of the photoresist composition.

11. The method of any one of claims 1 through 10 wherein the one or more photoacid generator compounds are ionic compounds.

12. The method of any one of claims 1 through 10 wherein the one or more photoacid generator compounds are non-ionic compounds.

13. The method of any one of claims 1 through 10 wherein the one or more photoacid generator compounds are onium compounds, imidosulfonate compounds, N-sulfonyloxyimide compounds, sulfonate ester compounds, nitrobenzyl compounds, disulfone compounds, and/or halogenated non-ionic compounds, or mixtures thereof.

14. The method of any one of claims 1 through 10 wherein the one or more photoacid generator compounds produce a halo-alkyl sulfonic acid upon exposure to activating radiation.

15. The method of any one of claims 1 through 10 wherein the one or more photoacid generator compounds produce a per-fluoro sulfonic acid upon exposure to activating radiation.

16. The method of any one of claims 1 through 15 wherein the resin comprises a polymer that contains phenolic units.

17. The method of any one of claims 1 through 15 wherein the resin comprises a polymer that contains phenolic and photoacid-labile alkyl acrylate units.

18. The method of any one of claims 1 through 15 wherein the resin comprises a polymer that contains 1) phenolic units, 2) phenyl units, and 3) photoacid-labile alkyl acrylate units.

19. The method of any one of claims 1 through 18 wherein the resin comprises a polymer that contains acetal, ketal or ortho ester groups.

20. A chemically-amplified positive photoresist composition comprising a resin and one or more photoacid generator compounds, wherein the one or more photoacid generator compounds are present in a concentration of at least about or greater than 5 weight percent based on weight of total solids of the photoresist composition, and the photoresist imageable with radiation having a wavelength of less than 100 nm, or electron beam or ion beam radiation.

21. A chemically-amplified positive photoresist composition on a substrate, the photoresist composition comprising a phenolic resin and one or more photoacid generator compounds, the resin comprising at least three distinct repeat units, the photoresist coating layer exhibiting, upon exposure to radiation having a wavelength of less than about 160 nm, or electron beam or ion beam radiation, enhanced photoacid generation efficiency as determined by Dill C-Parameter method to polymer containing solely phenolic and acrylate repeat units.

22. The photoresist of claim 21 wherein the one or more photoacid generator compounds are present in a concentration of at least about 5 weight percent.

23. The photoresist of claims 20 or 21 wherein the one or more photoacid generator compounds are present in a concentration of at least about 8 weight percent based on weight of total solids of the photoresist composition.

24. The photoresist of claims 20 or 21 wherein the one or more photoacid generator compounds are present in a concentration of at least about 10 percent based on weight of total solids of the photoresist composition.

25. The photoresist of claims 20 or 21 wherein the one or more photoacid generator compounds are present in a concentration of no more than about 12 percent based on weight of total solids of the photoresist composition.

26. The photoresist of claims 20 or 21 wherein the one or more photoacid generator compounds are present in a concentration of from about 10 to about 15 weight percent of total solids of the photoresist composition.

27. The photoresist of any one of claims 20 through 26 wherein the one or more photoacid generator compounds are ionic compounds.

28. The photoresist of any one of claims 20 through 27 wherein the one or more photoacid generator compounds are non-ionic compounds.

29. The photoresist of any one of claims 20 through 26 wherein the one or more photoacid generator compounds are onium compounds, imidosulfonate compounds, N-sulfonyloxyimide compounds, sulfonate ester compounds, nitrobenzyl compounds, disulfone compounds, and/or halogenated non-ionic compounds, or mixtures thereof.

30. The photoresist of any one of claims 20 through 29 wherein the one or more photoacid generator compounds produce a halo-alkyl sulfonic acid upon exposure to activating radiation.

31. The photoresist of any one of claims 20 through 29 wherein the one or more photoacid generator compounds produce a per-fluoro sulfonic acid upon exposure to activating radiation.

32. The photoresist of any one of claims 20 through 31 wherein the resin comprises a polymer that contains phenolic units.

33. The photoresist of any one of claims 20 through 31 wherein the resin comprises a polymer that contains phenolic and photoacid-labile alkyl acrylate units.

34. The photoresist of any one of claims 20 through 31 wherein the resin comprises a polymer that contains 1) phenolic units, 2) phenyl units, and 3) photoacid-labile alkyl acrylate units.

35. The photoresist of any one of claims 20 through 34 wherein the resin comprises a polymer that contains acetal, ketal or ortho ester groups.

35. <sup>36</sup> A negative photoresist composition comprising a resin and one or more photoacid generator compounds, wherein the one or more photoacid generator compounds are present in a concentration of at least about 5 weight percent based on weight of total solids of the photoresist composition, and the photoresist is imageable

with radiation having a wavelength of less than about 160 nm, or electron beam or ion beam radiation.

36. <sup>37</sup> The photoresist of claim 35 wherein the one or more photoacid generator compounds are present in a concentration of at least about 6, 7, 8, 9, 10, 11 or 12 weight percent based on weight of total solids of the photoresist composition.

37. <sup>2</sup> An article of manufacture comprising as substrate having coated thereon a photoresist composition of any one of claims 20 through 36.

38. <sup>38</sup> The article of claim 37 wherein the substrate is a microelectronic wafer substrate.

39. <sup>39</sup> The article of claim 37 or 38 wherein the photoresist coating has been imaged with radiation having a wavelength of less than about 160 nm, or electron beam or ion beam radiation.